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Effects of Facial Similarity on User Responses to Embodied Agents

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We investigated the effects of facial similarity between users and embodied agents under different experimental conditions. Sixty-four undergraduates interacted with two different embodied agents: in one case the agent was designed to look somewhat similar to the user, and in the other case the agent was designed to look dissimilar. We varied between subjects how helpful the agent was for a given task. Results showed that the facial similarity manipulation sometimes affected participants' responses, even though they did not consciously detect the similarity. Specifically, when the agent was helpful, facial similarity increased participantsi ratings of involvement. However, when exposed to unhelpful agents, male participants had negative responses to the similar-looking agent compared to the dissimilar one. These results suggest that using facially similar embodied agents has a potential large downside if that embodied agent is perceived to be unhelpful.

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1. INTRODUCTION

A decade ago, Nass et al. [1998] suggested that videoconferencing systems and virtual environments would facilitate the use of the user's own face as part of the interface. These authors showed that users who interacted with their own faces took the application more seriously, trusted the computer more, believed the computer was fairer, and took more responsibility for negative feedback [Nass et al. 1998]. In using photographs as embodied agents in a game context, De Bruine [2002] found that participants trusted agents that were facially similar to them more than agents that were not facially similar. Facial similarity also facilitates persuasion, especially when the embodied agent also mimics the user's nonverbal gestures [Ratan and Bailenson 2007]. Al-Natour et al. [2005] confirmed that personality and behavioral similarity positively affected customers' evaluations of automated shopping assistants. Similarly, Li et al. [2007] demonstrated that participants rated that agents were more influential when the agents' faces were facially similar to their own, compared to when the faces were dissimilar.

The findings from these studies are relatively intuitive. After all, physical appearance is an accessible and salient dimension along which people judge others (e.g., [Sangrador and Yela 2000]), and the face is considered one of the most important dimensions involved in social interactions [Sergent and Signoret 1992]. Facial characteristics may affect people at a glance. For example, people can be instantly and unconsciously affected by facial attractiveness [Langlois et al. 1991; Olson and Marshuetz 2005]. The similarity-attraction hypothesis posits that people resemblance in personality and appearance causes social influence [Byrne 1971]. For example, Hinsz [1989] showed participants photographs of real or randomly generated couples and asked them to rate the similarity between the faces. Actual couples showed higher facial similarities than the ad-hoc couples. Payne and Jaffe [2005] showed that in human-pet pairs sampled in pet beauty contests, a significant proportion of the partners showed higher facial resemblances than could be expected by random pair formation. Facial similarity even affects people's voting behavior during elections [Bailenson et al. 2008].

Nevertheless, the similarity-attraction hypothesis sometimes produces mixed results. Moreno and Flowerday [2006] tested the effects on learning and affect in students by using a multimedia program with or without an animated pedagogical agent for science education. They found that same gender yielded insignificant effects, and that the same ethnicity was preferred only by students with dark skin. Only in a few cases, however, this increased the learning and affect scores.

The current hypothesis is that participants might be less uncomfortable interacting with a facially dissimilar agent if that agent is unhelpful. We isolated these effects by measuring user involvement, distance, and use intentions. While previous literature has often treated these three factors as related or even identical, we examine them as unique constructs, and demonstrate that agent features and affordances differently affect user outcomes on each of the three measurements. In the next section, we discuss social comparison theory and emphasize that in the agent domain, affordances play an important role. We develop two hypotheses on how similarity in combination with agent affordances are expected to affect user responses—in particular, involvement with, distance towards, and intentions to use the agent. These hypotheses are further developed by relating them to the two emotion variables, relevancei and valence.

1.1 Similarity and Social Comparisons

Social comparison theory states that people constantly compare themselves to others [Festinger 1954; Heider 1946]. Faces, gender, ethnicity, personality, and attitudes are examples of dimensions on which people may compare themselves to others, including embodied agents (concerning agents, [Dryer 1999; Nass and Moon 2000; Nowak and Rauh 2005; Guadagno et al. 2007; Pratt et al. 2007]). One important motive for social comparison is that people want to make accurate self-evaluations [Festinger 1954]. Thus, when people compare themselves with another person on attributes similar to theirs, they unconsciously "look in the mirror" and evaluate not only the other person or agent, but also themselves.

There is abundant evidence that, more often than not, "similarity attracts" (e.g., [Byrne 1971; Chaiken 1979; Brock 1965; Cialdini 2001; Klohnen and Luo 2003]). In such cases, social comparison with other similar people should have positive consequences for self-evaluation. Based on the above studies, one would simply expect that people always prefer to use facially similar over dissimilar agents. However, alternatively, it may be the case that "opposites attract," and social comparison with similar others may result not only in attraction but also in rejection [Lerner and Agar 1972]. Likewise, people may not always approach similar others, but also avoid them. The reason is that there are other, *negative*, characteristics involved in assessing other social actors. Based on the negative characteristics of the similar other, people (unconsciously) activate negative self-associations and feel threatened in their personal identities [Lerner and Agar 1972]. One reason might be that people feel that interpersonal similarity on one dimension, such as personality, implies similarity on other dimensions [Heider 1946], including those perceived as unfavorable. Harshly evaluating a similar but unfavorable other person indicates dissociation and reduces the chance for people of being cast in the same negative light [Eidelman and Biernat 2003]. Thus, individuals undervalue a similar unfavorable other as a protection strategy that distances themselves from him or her.

Indeed, research has demonstrated that, under certain conditions, people are less favorable towards similar others than towards dissimilar others. Particularly, when similarity is paired with negative characteristics, such as unattractiveness, mental problems, or obnoxious behavior, similarity may have negative rather than positive implications. Taylor and Mettee [1971], for example, created similarity conditions by matching or mismatching personality traits of a participant and another person. When similar others were portrayed as pleasant, they were preferred over dissimilar others. However, when similar others were portrayed as obnoxious, participants preferred dissimilar others. Another study tested the effects of attitude similarity concerning prison reform [Silvia et al. 2005]. Republicans and Democrats listed either their own similarities to or differences from prisoners and then completed a survey of prison reform attitudes. Results showed that Democrats (a group with positive attitudes toward liberal prison reform) became even more positive when they considered their similarities to prisoners. Republicans (a group with negative attitudes toward liberal prison reform) became even more *negative* when they considered their similarities to prisoners. It seems, then, that in itself similarity evokes positive effects but that it can easily be overruled by characteristics that induce negative affect.

Because we are implementing facial similarity as part of a functional software agent, *affordance evaluations* are crucial. Affordances are the possibilities for action that the software offers to the user (search, help, etc.) [McGrenere and Ho 2000; Gibson 1979]. In early Microsoft Office versions, the interactive animated character Clippy was enabled by default to proactively assist users with their tasks.[1] If Clippy's suggestions were correct, he was likely to be perceived as having aiding affordances by users who wanted advice from the agent. If Clippy made suggestions that were irrelevant or incorrect, its affordances were likely to be perceived as obstructive. Thus, the affordances an agent offers can be perceived by the user as either aids or as obstacles, depending on the goal of the user [Van Vugt et al. 2006]. An obstructive affordance typically is perceived as a negative characteristic of an embodied agent, which might be detrimental to the positive effects of being facially similar to the user. No research has ever examined a facially similar agent that obstructs the user's goals. Therefore, we studied facial similarity (similar versus dissimilar) and affordance (aid versus obstacle) of embodied agents together and probed the combined effects on user responses.

1.2 User Responses: Involvement, Distance, and Use Intentions

We studied the combined effects of facial similarity and affordances on a number of measures. First, we measured the user's psychological *involvement* with and psychological *distance* towards the agent, which are related to user affect. Involvement refers to psychological approach tendencies (e.g., empathy, sympathy, challenge), and distance refers to psychological avoidance tendencies (e.g., antipathy, irritation, boredom). Traditional views on approach-withdrawal processes [Russell and Carroll 1999] consider involvement and distance one factor with the sign flipped. However, recent research in attitudinal ambivalence has claimed that the affect system should better be better conceived of as separate orthogonal positive and negative substrates [Cacioppo and Berntson 1994; Diener and Emmons 1985; Priester and Petty 2001]. We assumed, therefore,

[1]For example, see http://en.wikipedia.org/wiki/Office_Assistant.

that the two unipolar constructs of involving and distancing processes toward agents are preferable to the common bipolarity (for a more detailed explanation, see Konijn and Hoorn [2005]). Indeed, earlier research repeatedly found that experiences of involvement occur parallel to experiences of psychological distance [Konijn and Hoorn 2005; Konijn and Bushman 2007]. For example, people may experience both involvement and distance when an apparently virtuous person shows a dark side (e.g., Batman). Similarly, a user might feel sympathy for an agent and find him boring at the same time (e.g., a virtual newsreader). People can feel very attracted to an embodied agent because of its cute appearance and at the same time feel very distant from it because that appearance covers up spyware. For example, the appearance of the on-screen "intelligent software agent" Bonzi Buddy, a cute animated purple gorilla, was appreciated, but it also received wide recognition as spyware[2]). Because researchers are still debating whether positive and negative affect should be treated as one factor or as two separate factors [Brehm and Miron 2006], we treat involvement and distance as separate variables in the present study and we test whether this distinction is valid. For simplicity's sake, our hypotheses predict that involvement and distance are a mirror image of one another. Due to their unipolar nature, however, it may also turn out that the effects on involvement are absent whereas the effects on distance are significant, or vice versa.

In addition, we also measured intentions to use the agent. Intentions have been used in previous work as a proxy for behavior in general and for usage behavior in particular [Fishbein and Ajzen 1975; Ajzen 1991; Davis 1989; Venkatesh et al. 2003]. Affective responses (e.g., involvement, distance) and behavior (e.g., use intentions, actual use) do not always go hand in hand. For example, features of an intranet system that were actually used were also disliked [Saffer 2007]. Similarly, when users feel involved with an embodied agent "on a personal level," they may still decide not to use it because it is inefficient (e.g., in the case of irrelevant proactive behavior of Clippy). People may clearly feel psychologically distant to an agent but still use it, because they cannot perform a task any other way (e.g., buy a difficult to find product via a product presenter agent). Therefore, we treat involvement, distance, and use intentions as separate factors that are not necessarily interconnected.

The quality of affordances is an important predictor of involvement, distance, and use intentions [Van Vugt et al. 2006]. That is, an embodied agent with aiding affordances evokes high involvement and low distance as well as strong intentions to use the agent. An embodied agent with obstructing affordances evokes low involvement and high distance as well as intentions not to use the agent. The purpose of the current study is to examine how far facial similarity can boost or counter such general effects. Therefore, we expected that when people are confronted with an embodied agent with aiding affordances, facial similarity will increase involvement with and intentions to use the agent as well as decrease the distance felt towards the agent. When people are

[2]http://forum.insanelymac.com/index.php?showtopic=42702 and http://www.spywareguide.com/product_show.php?id=512(12/08).

confronted with an embodied agent with obstructing affordances, facial similarity will decrease involvement with and intentions to use the agent, and increase the distance felt towards the agent. In the second case, facial dissimilarity is preferred to facial similarity. Thus, we will test the following hypotheses.

H1 When an embodied agent has aiding affordances, facial similarity will lead to

(a) higher use intentions,
(b) higher involvement, and
(c) lower distance

than facial dissimilarity.

H2 When an embodied agent has obstructing affordances, facial *dis*similarity will lead to

(a) higher use intentions,
(b) higher involvement, and
(c) lower distance

than facial similarity.

Thus, we expected that under certain circumstances (H2), use intentions and involvement will be higher when the embodied agent does *not* resemble the user than when it does.

1.3 Differential Effects of User Characteristics

How users respond to an (facially similar) embodied agent does not only depend on the affordances an agent provides to the user, but also on a variety of user characteristics, such as gender, age, ethnicity, education, computer experience, and others ([Catrambone et al. 2004; Ruttkay et al. 2004]). For example, unskilled Word users might find proactive text-editing suggestions of an agent helpful, whereas skilled Word users might find them counterproductive for their tasks. Or a child might like to see the cute dog or cat blinking at her, whereas adults might find these pets annoying. Would that be the same for facially similar agents? One variable that has been examined specifically in relation to facial similarity is gender. De Bruine found that facial similarity increases the attractiveness of same-gender faces more than opposite-gender faces [De Bruine 2004a]. The effect occurred for both men and women who interacted with those faces [De Bruine 2002; De Bruine 2004b; De Bruine 2004a] Yet Nass et al. [1998], Li et al. [2007], and Ratan and Bailenson [2007] did not report any gender or age differences in their studies on facial similarity effects. In terms of interaction with agents in general, there has been research indicating that men and women interact differently with embodied agents on a social level. Women showed greater conformity with agents than men [Lee 2003, 2007] and female participants were affected by mutual gaze behavior of agents, whereas males were not [Bailenson et al. 2001]. In Bailenson et al. [2005], men recalled more verbal information from an agent's persuasive message than women did. Because the literature is mixed, we did not make predictions concerning differences in gender or other user characteristics. Nevertheless, we planned to control for these user characteristics in our experimental study and also examine the data for gender.

Another user characteristic that varies across individuals is goals and needs. Theories in psychology describe that, to a considerable extent, human action is goal-driven [Leontiev 1978; Gollwitzer and Bargh 1996]. People typically use an affordance because of a goal they want to achieve (e.g., finding information, having fun). Several strains of research are based on the idea that goals are central to human activity, for example in the communication sciences [Blumler and Katz 1974] and the field of human-computer interaction [Card et al. 1983; Kaptelinin and Nardi 2006]. The user-centered approach to designing computer systems [Norman 1988; Preece et al. 2002] also stresses the importance of looking into user goals, to create well-designed systems that users care for and use. Theories from psychology [Frijda 1986; Frijda 1988; Lazarus 1991] state that the *strength* of a human response is guided by the relevance of particular features of a stimulus to the human goals or needs. Similarly, an agent that is perceived as relevant by the user is likely to evoke stronger user responses (e.g., higher use intentions) than an agent that is perceived as irrelevant [Ajzen 1991; Venkatesh et al. 2003]. Furthermore, *valence* relates to the direction of human responses (positive versus negative) [Frijda 1986; Frijda 1988; Lazarus 1991]. In an embodied agent context, valence is the expectation of whether using the agent will lead to achieving user goals or not [House and Perney 1974; Van Vugt et al. 2006]. Valence is positive when users expect that the agent will help to achieve user goals and negative when users expect that the agent will lead them away from their goals. In general, relevance and expected goal achievement lead to a tendency to use the agent, whereas irrelevance and expected goal evasion lead to the tendency to not use the agent [Ajzen 1991; Venkatesh et al. 2003; Konijn and Hoorn 2005; Van Vugt et al. 2006].

Perceptions of relevance may depend on facial similarity. In the social comparison literature, perceived relevance is an important construct to understand the effects of (dis)similarity on the observer [Kruglanski and Mayseless 1990; Tesser 1988]. In general, similarity is not uniformly related to relevance [Kruglanski and Mayseless 1990]. In some cases, a similar other is perceived as more relevant than a dissimilar other. If someone suffers from arthritis, that person is more likely to follow the advice of another arthritis patient than of a migraine patient [Goethals and Darley 1977]. In other cases, a dissimilar other can also be perceived as more relevant than a similar other. The arthritis patient would listen more to the specialist, although that person does not suffer from the disease.

Facial similarity also may impact perceptions of valence. People may assess the behavior of an agent more positively when that agent is similar [Miller and Marks 1982; Mumford 1983; Ames 2004]. In the present study, we expected that facial similarity would alter the user's perceptions of relevance and valence, which consequently affect user involvement, psychological distance, and use intentions [Ajzen 1991; Venkatesh et al. 2003]. In other words, relevance and valence may serve as mediators between facial similarity and the various user responses (for a detailed explanation on mediation effects we refer Baron and Kenny [1986]). We tested the following hypotheses.

H3 The effects of similarity on involvement, distance and/or use intentions will be mediated through

(a) perceived relevance,
(b) perceived valence.

Yet, perceptions of relevance and valence also depend on the affordances of the agent. In a previous study, we found that affordances *in*directly affected the dependent variables (involvement, distance, and use intentions) via the mediation variables perceived relevance and perceived valence [Van Vugt et al. 2006]. After perceiving the affordance, users checked whether it was relevant to their goals and whether positive or negative outcomes could be expected from using the agent. This affected the intentions to use the agent. We expected that such mediation effects would also be present in the current study in the 3D-immersive virtual environment. We tested the following hypotheses:

H4 The effects of affordances on involvement, distance, and/or use intentions will be mediated through

(a) perceived relevance,
(b) perceived valence.

In sum, this study investigated the (combined) effects of design features (affordances and facial similarity) on use intentions and user engagement as well as the mediating roles of relevance and valence. It is important to note that we did not manipulate relevance and valence but rather studied their mediating effects.

2. METHOD

2.1 Overview of the Study

Most previous work on facial similarity applied morphing techniques to 2D faces (Bailenson et al. [2008] provide a review). With morphing techniques, a digital face of a participant and a face of an embodied agent can be combined into one new face. We employed morphing techniques to create 3D faces for embodied agents that resembled the face of the participants and tested our hypotheses in an immersive virtual environment. Each participant performed two tasks in virtual reality. Participants interacted with a facially similar embodied agent in one task and with a facially dissimilar embodied agent in another (factor *Designed similarity*). Half of the participants interacted twice with an embodied agent that provided good advice, whereas the other half interacted twice with an agent that provided bad advice (factor *Designed affordance*). After each task, participants completed a user perception questionnaire, in which we measured (1) the dependent variables involvement, distance, and use intentions, (2) perceptions of relevance and valence, (3) whether participants perceived the quality of the advice as aiding versus obstructing (*perceived affordances*), and (4) how facially similar participants perceived the agent to be to

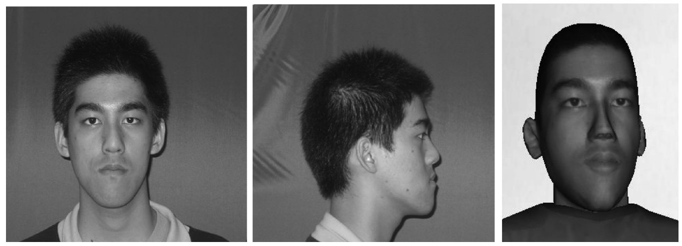

Fig. 1. A frontal and profile photo of a participant (left and middle) were converted into virtual busts attached to a virtual body (right).

them (*perceived similarity*). The distinction between actual similarity and perceived similarity is in line with work on interpersonal attraction (e.g., [Levinger and Breedlove 1966]).

2.2 Experimental Design

We used a 2 (*Designed similarity*: facial similar versus facial dissimilar) × 2 (*Designed affordance*: aid versus obstacle) experimental design to test our hypotheses. We manipulated designed similarity as a within-subject factor and designed affordance as a between-subject factor. Participants were randomly assigned to the designed affordance conditions. The order of the facial similarity conditions and the pairing of similarity conditions with other between-subjects conditions were varied according to a counterbalanced scheme. In addition, we used two different names and voices for the two agents with which participants interacted and counterbalanced these factors among the conditions. Neither order nor voice-type changed had any effects on the results.

2.3 Participants

Sixty-four university students (22 male, 42 female; M(age) = 20.5, SD(age) = 3.0) participated in the study for course credit. They were randomly assigned to the experimental conditions. The aid condition consisted of 12 males and 20 females and the obstacle condition consisted of 10 males and 22 females. Most participants (97%) spent more than 6 hours a week behind a computer and could be regarded as experienced computer users.

2.4 Stimuli

2.4.1 *Designed Similarity.* Frontal and profile photographs of 64 undergraduate students were taken in the laboratory during the first week of the academic quarter. Over the next 6 weeks, these photographs were converted into three-dimensional digital busts (Figures 1 and 2), using 3DmeNow photogrammetric software (see [Bailenson et al. 2004] for a thorough description of this process). The virtual busts were then 'morphed' with each participant's head bust using both geometric and textural algorithms from Vizard 2.53 (see Figures 1 and 2). Both geometry and textures were morphed at a 35% (participant)-65% (embodied agent) ratio because previous studies demonstrated that for 2D faces, this ratio is the optimal balance between manipulation

Fig. 2. The manipulation of facial similarity. An embodied agent head (left) is morphed with a participant head (middle), resulting in a new head (right).

effectiveness and non-detection of the morph ([Ratan and Bailenson 2007; Bailenson et al. 2008]). Consequently, as an additional contribution of our study, we explored whether the 35% self-similarity morph remained undetected in 3D virtual environments.

The head was morphed with a three-dimensional head bust of an embodied agent of the same gender. In total, we used four different male and four different female heads (heads used in a previous study of Yee and Bailenson [2007]) to reduce influences of the particular stimuli faces. A given female participant was morphed with one of the four female heads according to a counterbalanced scheme, which equalized the frequency of each head's use. After the morphing process was completed, the virtual busts were imported into a 3D science literacy VR application, using Vizard 2.53. Then the heads were attached to generic male and female bodies (see Figures 1 and 2).

2.4.2 *Designed Affordance.* We manipulated affordances in terms of the quality of advice an embodied agent would give to the participants while performing a science trivia test. Intelligent advice is likely to be perceived as an aid, whereas bad advice is likely to be perceived as an obstacle for task completion. Hence, in the aid condition, the embodied agent would give high quality advice (the distribution shows the correct answer as the highest bar in 10 out of 10 questions), and in the obstacle condition, the embodied agent would give low quality advice (the distribution shows the correct answer as the highest bar in only 2 out of 10 questions). Post-hoc tests confirmed this prediction (see manipulation check affordances in the Results section).

In total, we selected 20 difficult trivia questions with multiple choice. Pretests demonstrated that very few people knew the answers to these questions on science, technology, and industry. For each of the questions, only 25% guessed the right answer, which equals chance level. A sample question was "In the U.S., about how many gallons of milk does the average cow give during a year?" with the multiple-choice answers (A)1600, (B)1200, (C)1000, and (D)1400. Figure 3 shows an example of a trivia question and the embodied agent's advice, which was directing the user to either the correct or incorrect answer. The bars in the graph indicate how certain the agent was of each of the four answers, according to the affordance condition.

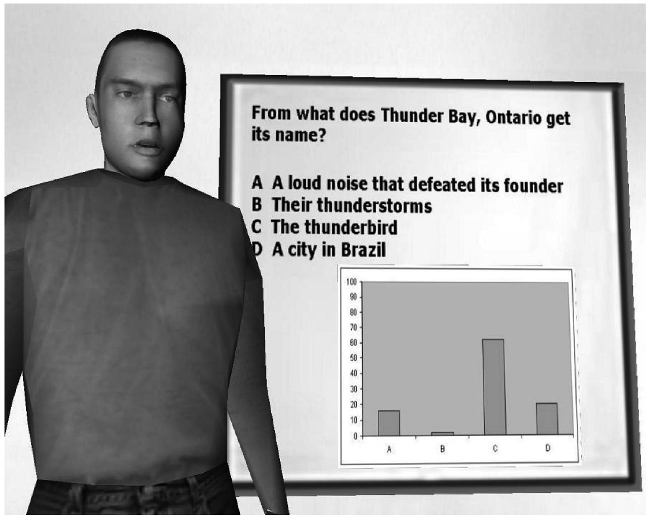

Fig. 3. An example of an embodied agent directing the user to the correct answer indicated by the highest probability bar (*aid* condition).

2.4.3 *The Assignment of Heads to Conditions.* Participants performed two tasks, each with a unique embodied agent as an advisor. Each participant always interacted with two embodied agents of the same affordance condition. In the first task, half of the participants interacted with an agent morphed with their own head, the virtual "self" (similar condition), and the other half interacted with an embodied agent morphed with another participant's head of the same gender, a virtual (dissimilar condition). In the second task, this was reversed. Participants who had interacted with their virtual self in the first task would interact with a virtual other in the second task, and vice versa. Thus, if a female participant's virtual self was morphed with female agent head 1, the virtual other would be another female participant's head morphed with female agent head 2, 3, or 4. An agent that was morphed with the head of participant A was seen by two participants: participant A (similar condition) and one other participant (dissimilar condition).

2.4.4 *The Virtual Setting.* The virtual setting was a white room with the same exact dimensions as the physical room where participants conducted the experiment. The embodied agent was located near the participant, facing the participant and standing next to a blackboard (see Figure 3). It had an automatic blink animation based on human blink behavior. The lip movements matched the volume of its speech, meaning that the mouth opened up (scales up on the Y-axis) as a direct function of the amplitude of the wave form of the audio file: The louder the utterance, the bigger the mouth opened.

2.5 Apparatus

Participants wore an nVisor SX HMD that featured dual 1280 horizontal by 1024 vertical pixel resolution panels that refreshed at 60Hz. The display optics

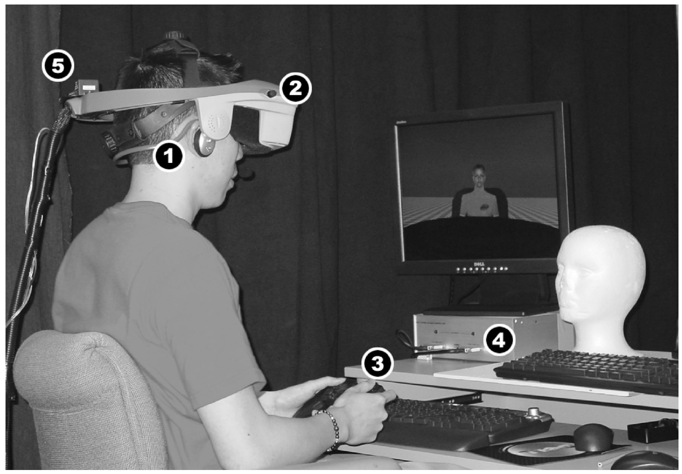

Fig. 4. A depiction of our immersive virtual environment system. The components are: 1) audio output device, 2) HMD, 3) game pad input device, 4) image generator, and 5) orientation tracking device.

presented a visual field subtending approximately 50-degrees horizontally by 38-degrees vertically.

A personal computer with an NVIDIA GeForce FX 6800 graphics Card rendered stereoscopic images for correct perception. These images updated at an average frame rate of 60Hz. The simulated viewpoint updated continually as a function of the participants' head movements. A three-axis orientation sensing system (Intersense IS250, update rate of 150Hz) tracked the orientation of the participant's head. The system latency or delay between a participant's head movement and the resulting concomitant update in the HMD's visual display was 45ms maximum. Vizard 2.53 software was used to assimilate the rendering and tracking. Participants used a Logitech RumblePad Pro game pad to interact with the virtual environment.

Participants answered post-experiment questionnaires on a standard desktop computer. See Figure 4 for equipment setup.

2.6 Procedure

One experimenter was present in the experimentation room. Participants were told they would perform two simple tasks within a virtual reality environment and that their assignment was to complete a questionnaire as best as they could. Next, they were told the following.

> This is unlike most questionnaires where you are on your own. Here, you will have the help of a virtual human. The virtual human is an intelligent agent that is designed to search for information on the Internet. You can choose to use the hints of the virtual human or not. It is completely up to you. In the computer, the correct answers are stored. The computer will tell you after each question whether you answered a question correctly or not. The virtual human does not have access to these correct answers, but reasons him/herself autonomously.

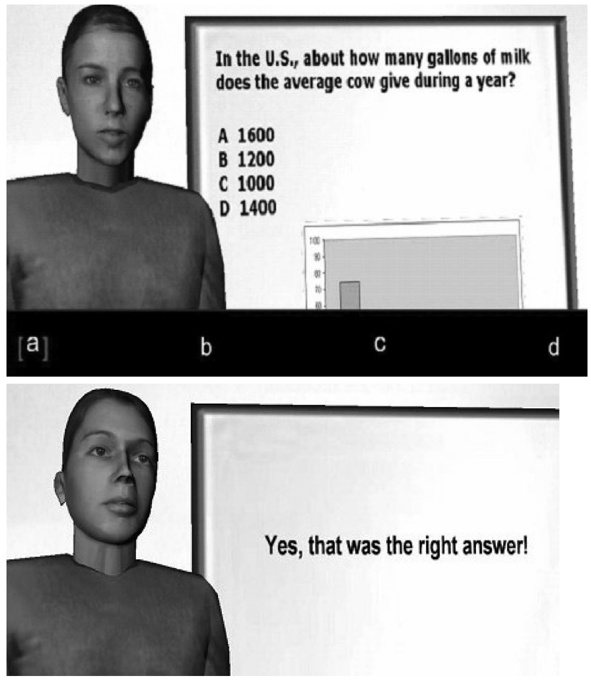

Fig. 5. Answer selection (top), and answer feedback (bottom).

Then, participants were seated on a chair in the lab, given a game pad and asked to put on the HMD (see Figure 4). Participants were asked by the experimenter to verify that they saw a virtual room. When the participant was ready, he or she would do a practice task within the virtual room to get used to the game pad for answer selection. The experiment began immediately afterwards. The experiment consisted of two tasks, with 10 questions in each task.

The embodied agent greeted the participant: “Hi, my name is Jane [John]. Your task is to respond to ten questions as best as you can. I will be your advisor.” Then, the virtual blackboard displayed at 3 second intervals: 1) a question, 2) the multiple choice answers, 3) a graph with the advice of the embodied agent, and 4) the selection categories A, B, C, and D (see Figure 5). At time interval 3, the embodied agent said, “In the graph you can see what I think the correct answer is. Please select your answer.” The participant selected an answer and pressed the OK button. They received immediate feedback on correctness of the answers (see Figure 5). A series of 10 questions were answered in this manner. Upon completion of all questions, the embodied agent said: “Thanks, and maybe I will see you again” Finally, the participant was asked to remove the HMD and complete the user perception questionnaire at a desktop computer in the lab.

Then, the second task was introduced by telling the participants that they would interact with a different virtual human. They were asked to put the HMD back on, and were greeted by the second embodied agent (“Hi, my name is Alice [Alex]. Your task is to respond to ten questions as best as you can. I will be your advisor."). The procedure was exactly the same as in the first task. After the second task, participants were asked what they thought the purpose of the study was. Finally, they were debriefed and thanked for participating in the study.

2.7 Measures

All measures were taken by means of a computer questionnaire containing construct specific scales (as recommended by Krosnick and Fabrigar [2007]). Each item was followed by a 6-point rating scale, ranging from 1 (Not _ at all), 2 (Very little _), 3 (Somewhat _), 4 (Quite _), 5 (Very _), to 6 (Extremely _). Existing scales were used whenever possible in the construction of the structured user-perception questionnaire (e.g., scales used in Van Vugt et al. 2006, 2007]). When necessary, items were translated and modified for the purpose of the investigation. The questionnaire consisted of 44 items in total.

Reliability analyses ($N = 64$) were performed on each set of items concerning separate scales. Selection criteria were 1) an optimal contribution to Cronbach's alpha by showing little or no increase in the alpha level when the item was deleted, 2) a minimal inter-item correlation of .60, 3) an interitem total correlation within a scale bigger than the correlation of each item with another scale (discriminant validity), and 4) a minimum of 2 items per scale. Items that failed on one or more of these criteria were not included in the measurement scales used in subsequent analyses.

We checked the affordance manipulations by means of a perceived affordance scale. To avoid the development of an affirmative answering bias [Dillman 2000], two items were indicative (e.g., "How knowledgeable do you think X is?") and two items were counter-indicative (e.g., "How dumb do you think X is?"). The scale was reliable (Cronbach's alpha = .91).

We used a perceived similarity scale to determine whether participants detected the resemblance between their face and the face of the agent. This scale consisted of two indicative items (e.g., "How much do you think you and X look alike?") and two counterindicative items (e.g., "How much do you think X looks different than you?") and was reliable (Cronbach's alpha = .90).

One item from the *use intention* scale was discarded because of poor fit (criterion 1). The remaining scale consisted of two indicative items (e.g., "How much do you want to use X again?") and one counter-indicative item ("How much do you want to get rid of X?"). The scale was reliable (Cronbach's alpha = .89).

Based on previous research, we assumed that involvement and distance are two distinct experiences that can occur at the same time. To demonstrate that involvement and distance should be treated as different factors and use intentions as a third factor, we performed factor analyses with the involvement and distance items used in the construction of these scales together with the three use intention items (varimax rotation, rotation converged in 6 iterations). Table I shows that the three use intention items all loaded high on factor 1 (and, with one exception, low on factor 2 and 3). The four distance items all loaded high on factor 2 (and, with one exception, low on factor 1 and 3). The four

Table I. Discerning the Factors *Involvement*, *Distance*, and *Use Intentions*, Using Factor Analyses in Both the Similar (Left) and the Dissimilar (Right) Condition

	Similar condition Component 1	Component 2	Component 3	*Dissimilar condition* Component 1	Component 2	Component 3
Involvement1	.488	−.266	**.688**	.806	−.189	**.370**
Involvement2	.226	−.136	**.842**	.127	−.083	**.912**
Involvement3	.030	−.046	**.893**	.441	−.084	**.800**
Involvement4	.571	−.119	**.534**	.538	−.322	**.569**
Distance1	−.126	**.892**	−.160	−.164	**.839**	−.160
Distance2	−.444	**.820**	−.009	−.300	**.883**	.042
Distance3	−.640	**.514**	.187	−.277	**.843**	−.046
Distance4	−.212	**.833**	−.281	−.080	**.846**	−.248
UseIntention1	**.865**	−.222	.226	**.886**	−.226	.141
UseIntention2	**.785**	−.265	.419	**.869**	−.270	.285
UseIntention3	**.566**	−.430	.398	**.602**	−.606	.120

involvement items loaded high on factor 3 (and, with two exceptions, low on factor 1 and 2) in both the similar and the dissimilar condition.

In addition, we calculated the correlation between the involvement and the distance factors, which was $r = -.42$ in the dissimilar condition, and $r = -.44$ in the similar condition. These low correlations indicated that involvement and distance should be treated as separate dimensions [Neter et al. 1990]. Both analyses justified treating the distance scale and the involvement scale as separate variables in subsequent analyses. The involvement scale consisted of four items (e.g., "How much does X appeal to you?", "How much do you feel connected to X?") and was reliable according to a Cronbach's alpha of .85. The distance scale consisted of four items (e.g., "How much does X leave you with cold feelings?") and was reliable according to a Cronbach's alpha of .89.

Finally, the questionnaire measured the factors of perceived relevance (3 items, Cronbach's alpha = .96) and perceived valence (4 items, Cronbach's alpha = .96) as potential mediators and included some questions regarding ethics, aesthetics, realism, and satisfaction (as in Van Vugt et al. [2006]). We also obtained personal information about the participants such as gender, age, ethnicity, education, computer experience, game experience, and virtual reality experience.

3. RESULTS

3.1 Morph Detection

To ensure that our similarity manipulation was not obvious to the participants, we asked them to guess the intent of the experiment. Most participants guessed that the study was about different appearances of the agent or about different voices. This was not surprising, as they indeed interacted with two agents with different appearances and voices in two tasks. Six out of sixty-four participants suggested that the study could have been about facial similarity. In addition, a univariate analysis of variance (ANOVA), with designed similarity as the within-subject factor and perceived similarity as the dependent variable, was conducted to evaluate whether participants perceived the agent that was morphed with their own face as more similar than the agent morphed with a different face. The results indicated that perceived similarity ratings did not differ significantly between the similar and the dissimilar conditions, M(similar) = 2.34, *SD* = .77; M(dissimilar) = 2.30, SD = .87; $F(1,59) = .215$, $p = .65$, partial eta-squared = .004. Thus, the similarity manipulation was not consciously perceived. The results of hypothesis testing did not change when we controlled whether participants had detected the facial similarity manipulation or not.

3.2 Manipulation Check Affordances

We assessed the effectiveness of the affordance manipulations (aid versus obstacle, or, high versus low quality advice) in both the similar and the dissimilar condition by performing an ANOVA with designed affordances as the between-subject factor, designed similarity as the within-subject factor, and perceived affordance as the dependent variable. The aid and obstacle conditions had a significant effect on perceived affordances, $F(1,58) = 69.35, p < .001$, partial eta-squared = .95. Participants perceived the embodied agent in the aid condition as having better affordances than the embodied agent in the obstacle condition, both in the similar condition, M(aid) = 4.81, SD = .90; M(obstacle) = 2.91, SD = .86, and the dissimilar condition, M(aid) = 4.73, SD = 1.0; M(obstacle) = 2.95, SD = .67. Thus, we successfully manipulated affordances by means of varying the quality of an agent's advice.

3.3 Testing Hypotheses

3.3.1 *Testing Hypotheses H1 and H2: Direct Effects of Similarity and Affordances on the Dependent Variables.* Univariate analysis of variance (ANOVA) is usually employed to test the effects of one or more manipulated variables (e.g., designed affordances and designed similarity) on a single dependent variable (e.g., involvement). Because we measured multiple dependent variables (involvement, distance, and use intentions), multiple analysis of variance (MANOVA) protects against observing an effect where there is none (a Type I error), which might occur if we had conducted multiple ANOVA's independently (for more information, see Neter et al. [1990], or Lattin et al. [2003]).

The design featured a number of independent variables. Half of our participants performed the tasks with an agent that gave good advice and the other half performed the tasks with an agent that gave bad advice. In other words, affordances were manipulated between subjects. Furthermore, in one task participants interacted with their virtual self and in the other task they interacted with a virtual other, so the similarity variable also was manipulated within subjects. The between-subject versus the within-subject design prompted the use of a mixed design MANOVA. Lastly, we controlled for several user characteristics (e.g., age, computer experience) in the data analyses and we tested whether the gender of the participant affected the user responses by including gender as an additional factor in the analyses.

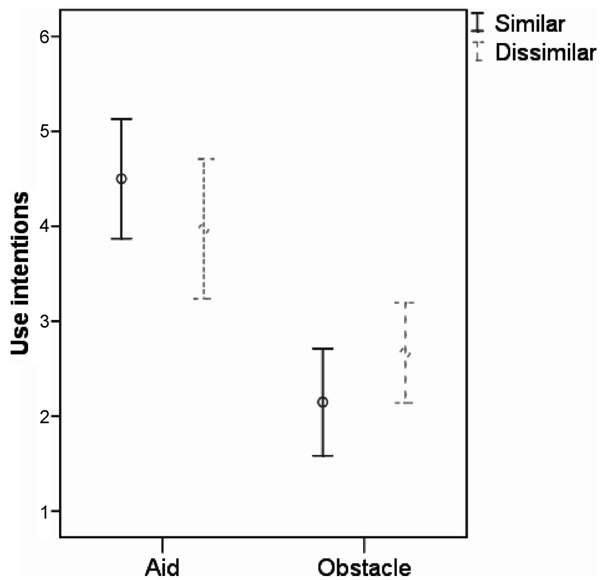

Fig. 6. The effect of designed similarity and designed affordance on males' intentions to use the agent again.

Thus, we performed a mixed MANOVA with designed similarity as the independent within-subject factor, designed affordance and gender as the independent between-subject factors, and involvement, distance, and use intentions as the dependent variables. The multivariate results revealed a main effect of designed affordance ($F(3, 58) = 37.61$, $p < .001$, partial eta-squared = .66) and an interaction effect of gender, designed similarity, and designed affordance ($F(3, 58) = 3.21$, $p < .030$, partial eta-squared = .14). No other main or interaction effects reached significance (ps $> .10$). To interpret these multivariate results, that is, the effects of the independent variables on the single dependent variables, it is common practice to run additional univariate ANOVAs. Thus, we conducted ANOVAs on each dependent variable as follow-up tests to the MANOVA.

Use intentions. First, designed affordance had a significant effect on use intentions ($F(1, 60) = 107.27$, $p < .001$, partial eta-squared = .64) (see Figure 6). For all participants, the aiding agent (M(aid) = 4.42) increased the level of use intentions as compared to the obstructing agent (M(obstruct) = 2.37) (Table II). Second, gender, designed similarity and designed affordance evoked interaction effects on use intentions ($F(1, 60) = 4.176$, $p < .045$, partial eta-squared = .07). For females, self-similar agents evoked higher use intentions (M(similar) = 3.54) than dissimilar agents (M(dissimilar) = 3.41), whether these agents were aids or obstacles. For male users, this was different. Self-similar and aiding male agents elicited a considerable level of use intentions (M(aid-similar) = 4.50) but this level dropped to its lowest point when the self-similar male agent was obstructive (M(obstruct-similar) = 2.14). For dissimilar male agents, this

Table II. Means and Standard Deviations of Involvement (I), Distance (D), and Use Intentions (U) in the Conditions of Designed Affordance (Aid Versus Obstacle) and Designed Similarity (Similar Versus Dissimilar)

		Aid condition	*Obstacle* condition
Similar condition	Males	*I* 2.48 (1.05)	*I* 1.83 (.51)
		D 1.56 (.52)	*D* 2.72 (1.45)
		U 4.50 (.98)	*U* 2.14 (.78)
	Females	*I* 3.06 (.73)	*I* 1.87 (.47)
		D 1.52 (.45)	*D* 2.28 (.84)
		U 4.70 (.68)	*U* 2.38 (.66)
Dissimilar condition	Males	*I* 2.33 (1.10)	*I* 1.87 (.78)
		D 1.81 (.84)	*D* 2.40 (.74)
		U 3.97 (1.15)	*U* 2.66 (.73)
	Females	*I* 2.78 (.77)	*I* 2.00 (.60)
		D 1.93 (.89)	*D* 2.60 (.87)
		U 4.51 (1.16)	*U* 2.30 (.69)

difference was less drastic. Dissimilar but aiding male agents provoked a level of use intentions of M(aid-dissimilar) = 3.97 and dissimilar and obstructing male agents a level of M(obstruct-dissimilar) = 2.66. This means that obstructing agents raised higher use intentions in males when they were dissimilar (M(obstruct-dissimilar) = 2.66) than when they were similar (M(obstruct-similar) = 2.14).

Involvement. First, designed affordance affected involvement ($F(1, 60) = 17.77, p < .001$, partial eta-squared = .228). Participants felt more involved with an aiding agent than an obstructing agent (see Table II). Second, the interaction effect of designed similarity and designed affordance on involvement was not significant but the data did show a trend ($F(1, 60) = 3.65, p < .061$, partial eta-squared = .057). Male and female users were more involved with an aiding agent who was facially similar to them than with a facially dissimilar one. This effect was not observed in the obstruction condition (see Table II).

Distance. Designed affordance had a significant effect on distance ($F(1, 60) = 16.74, p < .001$, partial eta-squared = .218). Distance was lower for an aiding agent than for an obstructing agent. No significant interaction effects on distance occurred (ps $> .05$).

3.3.2 *Testing Hypotheses H3 and H4: Indirect Effects of Facial Similarity and Affordances on the Dependent Variables.* To identify whether the similarity and affordance variables *in*directly affected the dependent variables (involvement, distance, and use intentions) via a third explanatory variable or mediator variable such as perceived relevance or perceived valence, we performed *mediation* analyses. A mediation model hypothesizes that the independent variable affects the mediator variable, which in turn affects the dependent variable. We performed several mediation analyses to test whether designed similarity indirectly affected the dependent variables (H3), and whether designed affordances indirectly affected the dependent variables (H4). To test mediation, we used the Sobel method [Preacher and Hayes 2004]. If the Sobel test indicates a significant effect ($p < .05$), we can conclude that mediation occurred. First, we used the Sobel method to test whether perceived relevance and perceived valence also mediated the relationship between designed similarity and the dependent variables of involvement, distance, and use intentions (H3). For both factors, however, the mediation effects were not significant (ps $> .10$).

Second, we tested whether perceived relevance and valence mediated the relationship between affordances and (one of) the dependent variables (H4). In both the similar and dissimilar conditions, the effect of perceived affordances on *(1) use intentions* was mediated by both perceived relevance (similar: Sobel $z = 6.70$, $p < .001$; dissimilar: Sobel $z = 5.40$, $p < .001$) and perceived valence (similar: Sobel $z = 5.90$, $p < .001$; dissimilar: Sobel $z = 5.09$, $p < .001$).

Third, the effect of perceived affordances on (2) distance was mediated by perceived valence in both the similar and dissimilar conditions (similar: Sobel $z = -2.01$, $p < .05$; dissimilar: Sobel $z = -2.68$, $p < .01$) and by perceived relevance in the dissimilar condition but not in the similar condition (similar: Sobel $z = -1.67$, $p = .09$; dissimilar: Sobel $z = -2.11$, $p < .04$).

Fourth, the effect of perceived affordances on (3) involvement was not mediated by perceived relevance (similar: Sobel $z = 1.03$, $p = .30$; dissimilar: Sobel $z = .24$, $p = .81$) nor by perceived valence (similar: Sobel $z = .97$, $p = .33$; dissimilar: Sobel $z = -.14$, $p = .89$) in both the similar and dissimilar condition.

Thus, H3a and H3b were not supported because no mediation effects of perceived relevance or valence occurred between designed similarity and the dependents. Instead, these factors mediated between perceived affordances as well as use intentions (supporting H4) and distance (supporting H4 but not for relevance in the similar condition). There were no mediation effects with involvement as the dependent (rejecting H4).

4. CONCLUSIONS

Our aim was to study the effects of facial similarity between agent and user under different conditions. More specifically, the agent had either aiding or obstructing affordances for the user—the agent was helpful or unhelpful. We predicted that facial similarity would cause positive effects on user responses in case of an aiding agent but negative effects in case of an obstructing agent. We also predicted that the effects of facial similarity and affordances on user responses would be indirect, via perceptions of relevance and valence. Independent variables were psychological involvement and distance (measures related to user affect) and use intentions (a measure related to user behavior).

Results demonstrated that participants were more willing to use an aiding agent than an obstructing agent. This result fits previous findings [Van Vugt et al. 2006]. For females, regardless of affordance condition self-similarity resulted in higher use intentions than self-dissimilarity (see Table II). Male users had higher intentions to use an obstructing agent that was facially dissimilar than one that was similar. With respect to H1a, on average participants were more willing to use an aiding agent that was facially similar than one that was dissimilar. Regarding H2a, males were less willing to use an obstructing agent that was self-similar than one that was dissimilar. Thus, H1a was supported for all users and H2a for males but not for females.

Participants reported higher involvement with an aiding agent than with an obstructing agent (see Table II), which fits previous findings [Van Vugt et al. 2006]. As a trend, H1b was confirmed in that all participants were more involved with a helpful self-similar agent than with a dissimilar agent. With obstructing agents, no significant effects occurred on involvement, rejecting H2b.

Further, participants felt less distant with an aiding agent than with an obstructing agent. This result also fits previous findings [Van Vugt et al. 2006]. No significant interaction between similarity and affordances occurred on distance, rejecting H1c and H2c.

Sobel tests indicated that no mediation effects of perceived relevance or perceived valence occurred between designed similarity on the one hand and involvement, distance, or use intentions on the other. Thus, we did not find support for hypotheses H3a and H3b. Designed similarity did not affect the dependents indirectly via perceptions of relevance and valence. Participants did not perceive the facially similar agent as more relevant to their goals nor as having higher outcome expectations than when the agent was facially dissimilar. By contrast, perceived affordances did affect use intentions, albeit indirectly, namely through perceptions of relevance and valence. Perceived affordances also indirectly affected distance towards the agent, through valence and, to a lesser extent, relevance. The effect of affordances on involvement was *not* mediated by perceived relevance or valence, regardless of similarity.

5. DISCUSSION

Our hypotheses were partially supported by the data. In general, both affordances and facial similarity impacted user affect and user behavior. Facial similarity had positive effects on use intentions and to a lesser degree on involvement in case of an aiding agent, confirming the idea that similarity attracts. For females, facial similarity as compared to dissimilarity increased use intentions, even with obstructing agents. However, the similarity-attraction hypothesis was not supported by the use intentions of males. When male users were confronted with an obstructing agent that was facially similar, they were less inclined to use it again than an obstructing dissimilar agent.

In terms of specific results, first, for aiding agents, both female and male users felt more involved with an embodied agent with aiding affordances when it was facially similar to them than when it was dissimilar. However, involvement with an embodied agent with obstructing affordances was equal for facially similar and facially dissimilar agents. There was a trend that facial similarity increased involvement, but only when the agent had aiding affordances.

Thus, the facial similarity of an obstructing agent did not have any effect. Psychological distance was unaffected by facial similarity and merely depended on the agent's affordances: Aiding affordances evoked less distance than obstructing affordances. Second, facial similarity affected intentions to use the agent. When the agent had aiding affordances, users were more willing to use a self-similar agent than a dissimilar agent. For females, this was even the case when the agent was obstructing. Males did not want to use self-similar agents that were obstructing. When the agent was obstructing, males preferred to use a facially dissimilar agent. Last, the effects of affordances on user responses were mediated through perceptions of relevance and valence but the effects of facial similarity were not. In line with previous results [Van Vugt et al. 2006, 2007], we found that perceptions of relevance and valence were affected by an agent's affordances. An aiding agent was perceived as more relevant; users expected more positive outcomes from using an aiding agent (positive valence) than from using an obstructing agent. Consequently, users felt less distant from the agent and had higher intentions to use it again. Thus, relevance and valence served as mediators in between affordances and various user responses.

Relevance and valence were not involved in effects of facial similarity on the user responses. Moreover, participants were unaware of the similarity manipulation. Ninety-one percent of the participants did not mention the facial similarity manipulation when asked about the purpose of the experiment, and explicit similarity ratings were equal among the designed similarity conditions. Thus, the facial similarity manipulation influenced participants' responses even though they did not explicitly detect it. Next, we discuss the implications of the study for designers, indicate the limitations of our work, and present ideas for future research.

5.1 Implications for Designers

Most designers aim to create helpful agents and therefore would be unconcerned with the facial similarity/dissimilarity of their embodied agents because they never anticipate their agents being unhelpful. There are two mistakes in this reasoning, however. Digital products fail to meet user goals with alarming frequency [Cooper et al. 2007] and therefore, agents can become unhelpful in the eyes of the user. In addition, while the effect is not universal, in many cases self-similarity *does* attract, in particular for females. Why waste an opportunity to increase user involvement and willingness to use an application? User involvement is an important predictor of user satisfaction [Lindgaard and Dudek 2003] and a prerequisite for better understanding [Falk and Dierking 2000]. For example, self-similarity in e-learning environments could render positive results [Johnson et al. 2000; Moundridou and Virvou 2002; Gulz and Haake 2006; Person and Graesser 2006; Aylett et al. 2007] but should not be applied uninformed.

As a general effect, it seems that people confronted with their self-image tend to regard the behavior of the image as their own [Nass et al. 1998]. In addition, facial similarity seems to engender greater self-awareness and induces higher responsibility for individual performance [Nass et al. 1998]. Moreover, people tend to overestimate their performance as a form of ego-enhancement [Nass et al. 1998] and men seem to do so more than women [Hill and Dusek 1969; Mura 1987; Beyer 1990; Beyer and Bowden 1997]. With regard to e-learning systems, then, designers should first of all know whether the affordances they design in a tutor or advisor are perceived as aids or obstacles. Affordances are responsible for the decision to use an application, feel involved with it, or feel detached. Moreover, affordances arouse emotions (via relevance to user goals) and affect the positive or negative expectations about the synthetic tutor. Similarity does operate through relevance, but merely strengthens the effect already caused by affordances. Similarity, then, should be carefully applied considering the gender of the user. For female users, self-similarity may cause positive effects on use intentions, irrespective of the performance of the agent. For males, this is different. Similarity is not attractive if the agent is unhelpful. As a design approach, an elearning system could at the opening start with an agent that is similarity-neutral and, depending on user performance, change into self-similarity when the user is performing well and change into dissimilarity when the user performs poorly.

5.2 Limitations and Future Work

A limitation of the present study is that it only examined same-gender interactions. Previous research showed several differences between same-gender and different-gender interactions. First, facial resemblance increases the attractiveness of same-gender faces more than opposite-gender faces [De Bruine 2004a]. Second, people have different expectations when they interact with a same-gender partner than with an opposite-gender partner [Rink and Ellemers 2006]. Third, in opposite-gender interactions, men and women behave in a less gender-stereotypical manner than in same-gender interactions [Carli and Eagly 1999; Guadagno and Cialdini 2007]. Because participants were in same-gender interactions in the current study, gender stereotypical behavior may have emerged. Future work may investigate how males respond to female agents that are self-similar and how females respond to self-similar male agents. Put differently, we should investigate how facial similarity affects users in opposite-gender interactions and examine how our results can be generalized.

In addition, the combination of facial similarity and affordances might be investigated in different task settings. For example, the user's task may require working with agents on virtual teams in collaborative virtual environments. In such settings, it may be important that these agents have a cooperative attitude, demonstrating similar interests as the user. Based on the current results, we expect that if agents are perceived as cooperative, facial similarity among team members may increase the user's involvement and use intentions. However, if agents are not perceived as cooperative, such agents should be facially dissimilar. This research will become important as collaborative virtual environments will become more prevalent in the future [Bailenson et al. 2005].

One may also study how facial similarity affects the user in more complex scenarios that are likely to exist in non-laboratory settings. In our experimental study, participants were instructed to focus on one particular goal, that is, they had to answer the questions the best they could. However, multitasking is common in virtual environments [Cypher 1986], and users may have multiple user goals, such as efficient task completion *and* enjoyment [Preece et al. 2002]. Future research may inspect the effects of facial similarity and the different effects of affordances and user gender in more complex settings. We used only a single level of morphing rate as low as 35% to study facial similarity and found an effect in a 3D virtual environment. However, the implicit aspect of the facial similarity morph might also explain why perceived relevance and perceived valence did not mediate facial similarity and user responses. The effects we found may increase with the degree of facial similarity involved. Future research should anticipate that participantsi awareness of the similarity manipulation might influence the results.

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